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Engineering Study: Waste Package and Cask Tilting Machine Design Development Plan

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WASTE PACKAGE AND CASK TILTING MACHINE

DESIGN DEVELOPMENT PLAN

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ACRONYMS

BWR	boiling water reactor
CHF	Canister Handling Facility
DDP	design development plan
DHLW	defense high-level waste
DTF	Dry Transfer Facility
FHF	Fuel Handling Facility
FMEA	failure mode and effects analysis
FTA	fault tree analysis
HLW	high-level radioactive waste
HVAC	heating, ventilation, and air-conditioning
ITS	important to safety
NSDB	*Nuclear Safety Design Bases for License Application*
PWR	pressurized water reactor
SNF	spent nuclear fuel
SSCs	systems, structures, and components

1. PURPOSE

The purpose of this design development plan (DDP) is to identify major milestones for advancing the design of the waste package tilting machine to meet its credited safety functions, as identified in *Nuclear Safety Design Bases for License Application* (NSDB) (BSC 2005), where this objective cannot be achieved by the use of commercially available components or the application of industry consensus codes and standards. Furthermore, this DDP defines the planned approach and schedule logic ties for the design development activities, if and when required, and provides a basis for the subsequent development of performance specifications, test specifications, and test procedures. At this time no design development needs have been identified for the waste package tilting machine

2. SCOPE

The scope and extent of this DDP are primarily driven by the development requirements defined within the *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005). This DDP applies to areas of the waste package tilting machine design where performance confirmation cannot be readily obtained through the use of standard systems, structures, and components (SSCs) (e.g., cranes) or consensus codes and standards. Since no such areas have been identified in the gap analysis, this document outlines the approach that will be used should design development requirements be identified as the design advances.

Only machines used to tilt waste packages are considered in this DDP. Equipment used to tilt transportation or storage casks are considered to be standard SSCs. In addition, some cask-tilting operations will be performed using other SSCs, such as the site rail transfer cart, which is considered in a separate DDP. Machines used to tilt casks are, therefore, outside the scope of this document.

The scope of this DDP is limited to identifying the planned approach and design development activities necessary to advance the design of the waste package tilting machine to demonstrate that it will meet its credited safety functions. Thereafter, this DDP will form the basis for defining design development and testing requirements within the waste package tilting machine performance specification. The performance specification will define the codes and standards and performance requirements for the design, fabrication, and testing of the equipment. Thereafter, testing activities will be detailed in test specifications and test procedures. Test specifications will detail the requirements for each test, and testing procedures will prescribe how each test is to be performed.

This DDP is prepared by the Spent Nuclear Fuel (SNF)/High-Level Radioactive Waste (HLW) System Team and is intended for the sole use of the Engineering department in work regarding the waste package tilting machine. Yucca Mountain Project personnel from the SNF/HLW System Team should be consulted before use of this DDP for purposes other than those stated herein or by individuals other than those authorized by the Engineering department.

3. PROGRESSIVE APPROACH

A practical design philosophy has been adopted relying on proven concepts and technology used by other similar nuclear facilities. Design development requirements and activities identified within this plan are commensurate with the level of design completed for license application and the associated gap analysis study. Accordingly, specific design details, or the selection of SSCs, may not be known, and all design development requirements may not have been identified within the gap analysis study.

For this reason, within this DDP, a progressive design development approach is presented that provides a framework whereby design development requirements and activities can be identified and detailed as the design advances. However, as the design advances, it is anticipated to the extent practical that components or SSCs that perform ITS functions will be selected based on proven technology and codes and standards that provide assurance that they will perform, as required, without need for extensive design development.

This progressive design development approach includes, as appropriate, the design development activities identified in Section 9. Completion of each design development activity and advancement of the design will determine the need for further design development and completion of additional design development activities.

This progressive approach will maintain flexibility throughout the design process to allow alternative solutions to be explored without compromising project design development objectives.

4. DESIGN DEVELOPMENT OBJECTIVES

The primary objective of this DDP is to identify the activities that extend beyond the codes and standards and supplemental requirements specified in *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005) and are utilized in advancing the design of the waste package tilting machine to meet its credited safety functions.

5. QUALITY ASSURANCE

This document was prepared in accordance with LP-ENG-014-BSC, *Engineering Studies*. The results of this document are only to be used as the basis for selecting design development activities; they are not to be used directly to generate quality products. Therefore, this engineering study is not subject to the requirements of *Quality Assurance Requirements and Description* (DOE 2004).

6. USE OF COMPUTER SOFTWARE

The computer software used in this study (Microsoft Word 2000) is classified as exempt from procedure LP-SI.11Q-BSC, *Software Management*. All software used to prepare this analysis is listed as software not subject to this procedure (LP-SI.11Q-BSC, Section 2.1).

7. FUNCTIONAL DESCRIPTION

Waste packages will be loaded and processed in the Fuel Handling Facility (FHF), Canister Handling Facility (CHF), and Dry Transfer Facility (DTF). The function of the waste package tilting machine (equipment number: 110-MJ-HTL0-TILT0001 [in DTF], 190-MJ-HTL0-TILT0001 [in CHF], 210-MJ-HEW0-WPTS0001 [in FHF]) is to support the bottom trunnions of the waste package during the tilting operation. The waste package is tilted onto an emplacement pallet on the waste package turntable. The cranes that handle loaded waste packages are categorized as ITS and required to prevent the drop of a waste package during a seismic event (BSC 2005). At all times while the waste package lower trunnions are locked onto the waste package tilting machine, the upper trunnions are locked onto the crane's yoke. Therefore, both the waste package handling crane and tilting machine must operate jointly to perform their required safety functions during the tilting process.

The waste package tilting machine is designed to support the following waste package types:

- 21-PWR (Absorber Plate and Control Rod)
- 12-PWR Long
- 44-BWR
- 24-BWR
- 5-DHLW/DOE SNF Long
- 5-DHLW/DOE SNF Short
- Naval SNF Long
- Naval SNF Short
- 2-MCO/2-DHLW.

Only a subset of the above waste package types will be processed in each facility and the specific design of the waste package tilting machine for each facility may, therefore, differ to accommodate these differences.

The waste package tilting machine is part of the waste package loadout subsystem, which is a part of the SNF/HLW transfer system. The waste package tilting machine is located in the canister transfer cell in the CHF, waste package loadout cell in the DTF, and main transfer room in the FHF.

The waste package tilting machine includes the following subcomponents:

- A trolley with a motorized drive train
- A trolley locking device
- A waste package trunnion support frame
- Trunnion locking devices.

The following is an example of the process steps where the waste package tilting machine is used:

1. The waste package tilting machine is unlocked and moved from its retracted position to the required position according to the waste package type being processed. The waste package tilting machine is then locked into place.

2. The trunnion locking device is prepared according to the waste package being processed.

3. The waste package arrives suspended vertically from a crane.

4. The waste package tilting machine provides pivot support pockets that interface with the lower waste package trunnions and locks the lower trunnions in position, but allows waste package rotation about this pivot point.

5. The crane lowers the upper end to position the waste package horizontally, and the waste package turntable lifts the emplacement pallet to support the waste package.

6. The trunnion collar locking devices on the crane and tilting machine are unlocked.

7. The crane yoke is retracted.

8. The waste package turntable lifts the waste package off the tilting machine.

9. The waste package tilting machine is unlocked, moved, and locked again at its retracted position.

8. NON-STANDARD SSCs

Non-standard SSCs are defined as SSCs that are not based on commercially available equipment, established industry practices, or consensus codes and standards. Non-standard SSCs and custom mechanisms whose failure modes may not be fully understood will need an investigation to determine the correlations to standard SSCs and if additional testing is needed to validate the assumptions. The majority of SSCs, mechanisms, and assemblies may appear non-standard; however, when broken down to a subcomponent level, they are often composed of standard component parts.

The preferred components are standard components whose failure modes and associated effects are well understood within industry and have their assigned reliability values documented. However, if subjected to an environment that is alien to their normal operation, such as radiation, contamination, and elevated temperatures, accelerated wear and failures could be encountered. Potential exposure to extreme seismic loads could affect standard equipment qualification. Determining a conservative derating factor to be attributed to the values normally assigned may need further investigation and validation.

Design confirmation of a non-standard SSC may be performed through various methods depending on the nature of the SSC. Some common examples include solid modeling, finite element analysis, and bench testing.

The *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005) identifies SSCs that perform ITS functions and the codes and standards to be used in the design, fabrication, and testing of the SSCs to provide assurance that they will perform as required. Supplemental requirements are identified in the gap analysis table when requirements for the SSCs extend outside the scope of the codes and standards.

There are currently no non-standard SSCs identified in the design of the waste package tilting machine; however, non-standard SSCs may be specified as the design progresses. The design development activities described below may be applied to both standard and non-standard SSCs as needed.

9. DESIGN DEVELOPMENT ACTIVITIES

If a design development requirement is identified, the following design development activities represent the progressive design development approach to advance the design of the waste package tilting machine. In turn, as the design advances, the need to complete each design development activity or selectively complete activities should be determined based on meeting each credited safety function. Design development activities are described in Section 10:

- Design Activities
  - Selection of SSCs
  - Engineering calculations
  - Computer modeling
  - Failure mode and effects analysis
  - Fault tree analysis (FTA)

- Testing Activities
  - Bench testing
  - Prototyping
  - Integrated testing.

As reflected in Appendix A, there are no specific design development requirements identified in the *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005). Although proven technologies and adaptations of similar designs will be used to the extent practical as the design advances, design development requirements may be identified in the future.

10. DESIGN DEVELOPMENT ACTIVITY DESCRIPTIONS

Based on the existing design of the waste package tilting machine, no gaps have been identified between the design and codes and standards used to meet the safety requirements. Therefore, no specific design development activities are identified in the *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005). The following design development activity descriptions are included to accommodate future design development needs, should they be identified.

10.1 SELECTION OF SSCs

To the extent practical, SSCs should be selected based on proven technology with demonstrated performance in similar environmental and operational conditions. SSCs with a proven pedigree and known and well-documented history may significantly reduce the need for subsequent design development. The selection of new technologies could require testing to confirm the adequacy of the SSC design under normal, abnormal, design basis event, post-design basis event conditions, and the suitability of materials and methods of construction.

10.2 ENGINEERING CALCULATIONS

The structural, mechanical, instrumentation and control, and electrical design of the waste package tilting machine will be developed in compliance with the codes and standards and supplemental requirements identified in the *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005). The codes and standards identify required calculations, modeling, and testing necessary for the ITS SSCs. Supplemental requirements were identified in the *WP Tilting Machine—Gap Analysis Table* applicable to ITS SSCs. The design process also allows for other codes and standards to be used, upon approval, with the use of new SSCs proposed to satisfy the safety requirements.

If, during the structural, mechanical, instrumentation and control, and electrical design tasks, necessary evaluations are identified that are outside the identified codes and standards, a design development activity may be executed. General assembly drawings may be developed, and applicable SSCs will be evaluated through engineering calculations.

The design progression will determine if additional engineering calculations are required to satisfy the safety requirements.

10.3 COMPUTER MODELING

If necessary, computerized simulation program (3D) modeling may be conducted for design confirmation during the evolution of the waste package tilting machine design to ensure the SSCs perform ITS functions without interference. Interfaces between waste package tilting machine SSCs and interfaces with other SSCs will be evaluated for acceptable performance during the design activities in conjunction with the codes and standards identified in the *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005).

The waste package tilting machine interfaces with the following equipment or systems may include ITS functions:

- Building floor
- Waste package trunnion collar
- Waste package turntable
- Waste package handling crane and yoke (tilting operations)
- Electrical power system.

Finite element modeling may also be used as a design development activity to provide supporting evidence that design stress levels are not exceeded, especially for complex components.

The design progression will determine if additional computer modeling is required to satisfy the safety requirements.

10.4 FAILURE MODE AND EFFECTS ANALYSIS

A failure mode and effects analysis (FMEA) may be performed using ANSI/IEEE Std 352-1987, *IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Protection Systems.*

When identified as a design development activity, the FMEA is usually the first reliability activity performed to provide a better understanding of a design's failure potential. It can be limited to a qualitative assessment, but may include numerical estimates of a failure probability. Important applications of the FMEA include the following:

- Specification of future tests that is required to establish whether or not design margins are adequate relative to the specific failure mechanisms that have been identified in the FMEA.

- Identification of acceptable versus unacceptable failures for use in the quantitative evaluation of safety-related reliability.

- Identification of critical failures that may dictate the maintenance philosophy and frequency of operational tests or maintenance intervals if these failure modes cannot be eliminated from the design.

- Establishment of the level of parts quality (particularly true in electrical systems) needed to meet allocated reliability goals.

- Identification of the need for design modifications to eliminate unacceptable failure mechanisms. These failures could produce unacceptable safety or operational conditions.

- Identification of the need for failure detection.

The FMEA may be used to identify, by component, all known failure modes, failure mechanisms, effects on the system, methods of failure detection, and what provisions are included in the design to compensate for the failure. The analysis should provide established reliability statistics based on failure rates for components used in similar applications and environmental conditions. Reliability data, where available, will be obtained from facilities with similar quality control requirements. This activity is a prerequisite to performing a detailed FTA and provides the first level of design confirmation during the conceptual design phase. Where data cannot be obtained from sources that reflect comparable environmental exposure, the bench testing results should be used to adjust, where necessary, the reliability values for individual components. The FMEA should be periodically updated to reflect changes as the design matures.

10.5 FAULT TREE ANALYSIS

An FTA may be performed using ANSI/IEEE Std 352-1987.

When identified as a design development activity, the FTA is used to ensure that the SSCs will perform their intended safety functions with the reliability required by the NSDB either explicitly or implicitly. An FTA, when used in conjunction with the results of an FMEA and potential bench testing, should provide adequate design confirmation to make the decision whether to proceed with prototype testing or offsite integrated testing or both. Alternatively, any negative FTA results may indicate that the design (either preliminary or detailed) needs to be further revised for the SSC to meet the established safety requirements.

Important benefits of FTA are:

- Identify possible system reliability requirements and needs or failure faults during design.
- Assess system reliability or safety during operation.
- Identify components that may need testing or more rigorous quality assurance scrutiny.
- Identify root causes of equipment failures.

10.6 BENCH TESTING OF COMPONENTS

Bench testing is not expected for waste package tilting machine SSCs. The design progression will determine if bench testing is required to satisfy the safety requirements.

10.6.1 Purpose of Bench Testing

The purpose of bench testing is to provide confirmation and reassurance that appropriate values are being used in the FMEA and FTA performed on the detailed design. Components that do not have a proven history for operating in a similar environment shall be considered for bench testing.

10.6.2 Bench Testing Requirements

Bench testing shall be performed at a testing facility capable of handling the testing environment to demonstrate that each component is capable of performing its safety function under representative environmental conditions. Environmental conditions should be established based on bounding relevant environmental conditions while under loads representative of the bounding load combinations. Testing shall be in a nonradioactive environment unless necessary.

The development of test plans and procedures is not detailed in this description but is mentioned as a necessary step for each phase of bench testing.

10.6.3 Rationale for Selecting Components for Bench Testing

Bench testing can be applied to components, assemblies, or the entire piece of equipment. The selection of these components should consider their influence on test results. Where practical, components that are identified as ITS shall be identical to those used in the final production unit.

Components that do not have a proven history of operating within a similar environment should be subject to bench testing. In order of priority, the following list identifies those components that should be tested:

1. Novel components with no pedigree
2. Environmentally sensitive components (such as unshielded electronics)

3. Standard components whose unique configuration exposes them to potentially unknown failure modes in the unique environment.

10.7 PROTOTYPE TESTING

Prototype testing is not expected for waste package tilting machine SSCs but is included as a complete description for satisfying SSC design solutions.

During fabrication it may be necessary to demonstrate the functionality of certain SSCs to confirm that the ITS functions perform as required. Prototype testing can be applied to individual components, assemblies, or the entire equipment. The basic approach is to test the critical systems in an environment that simulates the actual operating environment as closely as possible. The development of test plans and procedures will ensure that the ITS functions are tested in relevant conditions and the required performance is monitored.

Recognizing that there may be restrictions on the physical size and capacity of test facilities available, it may be more appropriate to test at the component level rather than testing entire assemblies. The selection of individual components should consider their influence on test results. Where practical, components that are identified as ITS should be identical to those to be used in the final production unit.

Prototype testing should be performed in the following sequential phases to the extent required to meet acceptance criteria:

1. Phase I: Accelerated Testing
2. Phase II: Extended Testing
3. Phase III: Sustained Testing.

The design progression will determine if prototype testing is required to satisfy the safety requirements.

10.7.1 Accelerated Testing

Accelerated testing should simulate the full life-cycle operations of the component or assembly for identified parts (e.g., controllers, brakes, and bearings) under representative operating conditions. Life-cycle operations should be based on all normal movements associated with the throughput of the equipment as described in the system description document and should take into account the anticipated replacement frequency.

Appendix B is used to tabulate ITS SSCs and prototype accelerated tests. No prototype testing is anticipated for the waste package tilting machine.

10.7.2 Extended Testing

Extended testing should simulate extended life-cycle operations for ITS moving parts of the waste package tilting machine or components (e.g., trunnion locks, motors, and speed controllers) under representative operating conditions. Extended life-cycle operations should be based on all normal movements associated with the SSC operational cycles, plus margin for the operating period of the component prior to replacement.

Appendix B is used to tabulate ITS SSCs and prototype extended tests. No prototype testing is anticipated for the waste package tilting machine.

10.7.3 Sustained Testing

Sustained testing should simulate the performance of the waste package tilting machine or its components under off-normal environmental and operating conditions. Off-normal conditions should include, but are not limited to, temperature extremes, over speed, over travel, collisions, off-set loads, loss of power, derailments, and rail misalignment.

The anticipated frequency of the off-normal events should drive the number of cycles a test is performed. For example, the seismic qualification of a component need only be tested using either a static equivalent force applied over an hourly period or a time history of the forces derived from analysis. Off-normal temperature conditions, perhaps caused by heating, ventilation, and air-conditioning (HVAC) system failure, may warrant a test whose duration matches the mean time to repair the HVAC system.

Sustained testing should be performed at the end of extended testing. This will provide confidence that the SSCs will perform as designed during off-normal events, even at the end of their intended lifecycle, to account for the effects of normal or extended wear and tear.

Damage or malfunction of the SSCs during sustained testing may require that the design be revised (if the SSCs do not meet the intended safety requirement) or repaired or replaced if the damage is minor and does not impact the intended safety function. This would only be necessary if multiple and sequential sustained tests are envisioned. The repaired or replaced component may then have to undergo another cycle of accelerated and extended testing prior to the next sustained test.

Appendix B is used to tabulate ITS SSCs and prototype sustained tests. No prototype testing is anticipated for the waste package tilting machine.

10.8 OFFSITE INTEGRATED TESTING

Following fabrication and the manufacturer's tests and inspections, offsite integrated testing may be identified as a design development activity to demonstrate and confirm that the ITS functions and interfaces perform as required. To the extent practical, the offsite integrated testing may be used to demonstrate the performance of the ITS SSCs under simulated operational conditions, including each applicable waste package type. The development of test plans and procedures will ensure the ITS functions are tested in the proper conditions and that the required performance is monitored.

Testing may be specified to support the following:

- Demonstrate ITS functionality of the system under simulated operational conditions.
- Permit early hands-on involvement of regulatory agencies.

- Permit early operator training capabilities.
- Provide early feedback for needed modifications or design enhancements.

The design progression will determine if offsite integrated testing is required to satisfy the safety requirements.

10.9 OPERATIONAL READINESS REVIEW

Although operational readiness review is beyond the scope of this DDP, it is mentioned here for completeness. The operational readiness review should follow offsite integrated testing and highlights the final milestone in demonstrating the performance of production ITS SSCs.

11. INFORMATION COLLECTION AND INSPECTION REQUIREMENTS

The primary objective of information collection and inspection requirements is to document the performance of the design. Component failure or excessive wear may be influenced by interactions. Thus, to evaluate component failures that influence reliability, it is essential that information be collected during each stage of the component life (i.e., manufacture, construction, testing, and operation). This information may then be used to ensure that a root cause analysis can be performed on those components that do not meet their intended design and performance objectives.

Appendix C is used to identify typical data collection requirements. No data collection activities beyond those required by the codes and standards and supplemental requirements are anticipated for the waste package tilting machine.

11.1 BASELINE DATA

To assess wear and failure modes of ITS components during and after testing, it may be essential that detailed baseline data be obtained. The data, at a minimum, should include a physical inspection of each component before and after testing to identify defects and anomalies. Typical data should include weights, key dimensions, and surface finishes.

11.2 ACCELERATED TEST DATA

Throughout life-cycle prototype testing, sufficient instrumentation may be utilized to monitor the performance of ITS components. Instrumentation should provide real-time monitoring and feedback on key measurement and operating parameters. Measurements, as a minimum, should include temperature, loads, and speeds, depending on ITS safety functions to be verified and physical parameters to be monitored. Instrumentation, where practical, should include visible and audible feedback.

During accelerated testing, components may be inspected and maintained (adjusted or lubricated) as part of a scheduled maintenance regime based on vendor data. Where practical, vendor data should be supplemented with predictive maintenance and condition monitoring techniques.

11.3 EXTENDED TEST DATA

Data requirements for extended testing are similar to those for accelerated testing, with the exception that a detailed inspection of each ITS component needs to be performed prior to testing to determine component compliance with specifications, wear, and life expectancy.

11.4 SUSTAINED TEST DATA

Data requirements for sustained testing are similar to those for accelerated testing, with the exception that a detailed inspection of each ITS component needs to be performed after each sustained test evolution to monitor for the evidence of progressive and cumulative fatigue or component failure.

11.5 OFFSITE INTEGRATED TEST DATA

Following fabrication, including the manufacturer's tests and inspections and, where applicable, the prototype testing of SSCs, it may be necessary to demonstrate the overall functionality of the complete system ITS functions. This phase of testing is referred to as integrated testing. To the extent practical, integrated testing will be used to demonstrate the performance of the complete system under simulated operational conditions. Prior to offsite integrated testing, equipment used should be refurbished or replaced to a new condition. Data collection for integrated testing should be representative of real operations. Test conditions should also be representative, with the exception of the presence of a radiation source. Where possible, interfacing SSCs should be included in the final stages of testing to prove, where in doubt, that the integration of various components operate as intended. When determined necessary, integrated testing is highly recommended to support meeting the following goals:

- Demonstrate ITS functionality of the complete system under simulated operational conditions.
- Demonstrate practicality of recovery and retrieval plans (when applicable).
- Permit early hands-on involvement of regulatory agencies.
- Permit early operator training capabilities.
- Provide early feedback for necessary modifications or design enhancements.

12. EXPECTED RESULTS AND ACCEPTANCE CRITERIA

The following subsections outline the generic expected test results and acceptance criteria based on satisfying the ITS requirements specified in the NSDB (BSC 2005). Reported deviations from these expectations should be subject to close inspection and further the evaluation. If necessary, additional testing may be required to verify data or provide additional information to enable a conclusive root cause analysis to be performed.

12.1 ACCELERATED TESTING

The completion of accelerated testing will demonstrate the satisfaction of applicable ITS reliability requirements specified in the NSDB (BSC 2005).

12.2 EXTENDED TESTING

Extended testing should provide added confidence that ITS reliability requirements can be met with a degree or margin over an extended operational life. Therefore, successful extended testing should conclude with results that further support accelerated testing.

12.3 SUSTAINED TESTING

Sustained testing should provide added confidence that ITS reliability requirements can be met with a degree or margin under off-normal conditions. Therefore, successful sustained testing should conclude with results that further support accelerated and extended testing.

12.4 OFF-SITE INTEGRATED TESTING

Off-site integrated testing will provide assurance the system will perform all required safety functions and that interactions with other equipment interfaces including recovery systems are as specified. During this testing, improvements may be highlighted that will be incorporated prior to delivery and installation of the equipment on site.

13. LOGIC TIES TO DESIGN ENGINEERING, PROCUREMENT, AND CONSTRUCTION

Appendix D identifies logic ties to the design engineering, procurement, and construction schedule. These ties are based on major design development milestones of the waste package tilting machine. As stated previously, no design development requirements have been identified for the tilting machine and the information in Appendix D is provided as an example only.

14. REFERENCES

The following documents were used in the preparation of this report:

ANSI/IEEE Std 352-1987. *IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Protection Systems.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 246332.

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APPENDIX A: ITS SSCs DESIGN DEVELOPMENT NEEDS

NSDB Requirement	Applicable SSC	Design Development Needs					Comments
		Required Analysis	Required Drawings	Required Calculations	Required Modeling	Required Testing	
The waste package tilting machine system shall be designed for loading conditions associated with a DBGM-2 seismic event to maintain stability and prevent a waste package drop or slapdown. In addition, an analysis shall demonstrate that the waste package tilting machine system has a sufficient seismic design margin to ensure that no drop and no slapdown safety functions are maintained for loading conditions associated with a BDBGM seismic event.	All load path SSCs	N/A	N/A	N/A	N/A	N/A	Design development satisfied by codes and standards and supplemental requirements
The waste package tilting machine shall be designed to prevent backward slapdowns.	Mechanical backstop device	N/A	N/A	N/A	N/A	N/A	Design development satisfied by codes and standards and supplemental requirements
The waste package tilting machine shall include measures to prevent the movement or release of the lock on waste package trunnions while the waste package is being lowered onto the emplacement pallet.	Trolley locking device Trunnion locking device Instrumentation and control devices	N/A	N/A	N/A	N/A	N/A	Design development satisfied by codes and standards and supplemental requirements
An impact or collision between the waste package tilting machine and a waste package shall not breach the waste package or cause it to fall off the emplacement pallet.	Interlock with waste package turntable Translation motor Torque limiter Trolley locking device	N/A	N/A	N/A	N/A	N/A	Design development satisfied by codes and standards and supplemental requirements

NOTE: BDBGM = beyond design basis ground motion; DBGM = design basis ground motion.

APPENDIX B: ITS SSCS PROTOTYPE TESTING

ITS SSCs Prototype Testing	
ITS SSC	**Test**
No prototype testing of ITS SSCs is anticipated for the waste package tilting machine.	N/A

APPENDIX C: ITS SSCs DATA COLLECTION

ITS SSCs Data Collection	
ITS SSC	**Potential Data Collection**
No data collection of ITS SSCs is anticipated for the waste package tilting machine.	N/A

APPENDIX D: WASTE PACKAGE TILTING MACHINE DESIGN DEVELOPMENT MILESTONES

Design Development Activity	Development Activity Description	Project Phase	P3 Logic Tie Activity ID[a]	P3 Logic Tie Activity Description[a]	Target Start[a]	Target Finish[a]
Selection of SSCs	Selection of SSCs for detailed design	Procurement—Development of performance specification Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
Engineering Calculations	Structural and mechanical design	Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
			RPXK750S	MH Fabrication	Oct 2007	Sep 2008
	Instrumentation and control and electrical design	Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
Computer Modeling	Interference and interface verification	Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
Fault Mode and Effects Analysis	FMEA of detailed design	Procurement—Development of performance specification Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
Fault Tree Analysis	FTA of detailed design	Procurement—Development of performance specification Procurement—Detailed design by vendor	RPXK750N	MH Vendor Design	Mar 2007	Oct 2007
Bench Testing	Bench testing • Test preparation and procurement • Accelerated testing • Extended testing • Sustained testing	Procurement—Detailed design by vendor	RPXK750S	MH Fabrication	Oct 2007	Sep 2008
Prototype Testing	Prototype testing • Test specification and procedure • Vendor test	Procurement—Detailed design by vendor	RPXK750U	MH Vendor Shop Test	Sep 2008	Oct 2008
Integrated Testing	Offsite integrated testing (nonradioactive) • Test specification and procedure • Testing	Detailed design by vendor	RPXK750U	MH Vendor Shop Test	Sep 2008	Oct 2008

NOTES: [a]Logic tie activity IDs, descriptions, and start/finish dates are the same as for the trunnion collar removal machine.
No design development activities are anticipated for the waste package tilting machine; however, the codes and standards and supplemental requirements given in *WP Tilting Machine—Gap Analysis Table* (COGEMA 2005) cover many of the above activities.
MH = mechanical handling